INFLUENCE OF ORIGIN OF THE BEANS ON PROTEIN QUALITY AND NUTRITIVE VALUE OF COMMERCIAL SOYBEAN MEALS

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Objectives

Soybean meal (SBM) is the main source of protein in poultry diets. Different factors such as environmental conditions during growing of the beans, crushing methodologies, and length of storage might affect nutrient contents, amino acid profile, and protein quality variables (Grieshop and Fahey, 2001; Karr-Lilienthal et al., 2004; Thakur and Hurburgh, 2007). This work was conducted to determine the differences on SBM nutritive values among the three main origins available in the EU market. The influence of crop year was also evaluated by comparing analytical data of samples collected during yr 2012 with those of the previous 5 yr. Correlations between chemical components of SBM were studied to identify differences and provide recommendations for evaluation of the nutritive value of SBM according to the origin of the bean.

Materials and methods

A total of 389 SBM batches were sampled from 2007 to 2011 (n = 126 from Argentine; ARG; n = 114 from Brazil, BRA; n = 149 from USA) and 90 extra batches (30 per each country) were sampled during yr 2012. Samples were collected directly in the country of origin (64%) or at arrival of the vessel at European ports. Soybean meal samples were analyzed for chemical components as indicated by AOAC International (2000). Urease activity (UA), trypsin inhibitors activity (TIA), protein dispersibility index (PDI), and KOH solubility (KOH) were determined as described by Frikha et al., 2012. Amino acids (AA) and heat damage indicator (HDI) were determined by NIRS using the Aminored method (Evonik, 2010).

Data were analyzed as a completely randomized design using the GLM procedure of SAS Institute Inc. (1990) with origin of the bean, period of collection and its interaction as main effects. Pearson correlation analyses were determined to establish the relationships between the different variables studied. A probability value of 0.05 was considered significant. Data are presented as LSMEANS in tables.

Results

Origin of the beans influenced ($P < 0.001$) all nutritive values of SBM (Table 1), except for UA ($P < 0.01$) and ether extract ($P > 0.05$).

On DM basis, USA meals (n=179) had more CP (53.7 *vs.* 51.6 *vs.* 53.0%), sucrose (8.3 *vs.* 7.6 *vs.* 6.5%) and stachyose (6.5 *vs.* 5.6 *vs.* 5.2) but less crude fiber (4.3 *vs.* 5.3 *vs.* 6.2%), NDF (8.9 *vs.* 10.4 *vs.* 11.9%1) and raffinose (1.1 *vs.* 1.3 *vs.* 1.6%) than ARG (n=156) and BRA meals (n=144). Mineral content of meals also differ among origins; USA SBM had more P (0.78 *vs.* 0.75 *vs.* 0.70%) and Ca (0.39 *vs.* 0.37 *vs.* 0.33), but K (2.49 *vs.* 2.56 *vs.* 2.30) was intermediate between ARG and BRA meals. The amino acid profile (% CP) varied with the origin. Lysine was higher (6.15 *vs.* 6.09 *vs.* 5.96%) for USA than for ARG and BRA meals. The content of met+cys (2.87 and 2.87 *vs.* 2.81%), thr (3.93 *vs.* 3.91 *vs.* 3.88%), trp (1.37 *vs.* 1.36 *vs.* 1.34%) and the sum of these 5 key AA were higher for ARG and USA than for BRA, respectively.

The average protein quality of SBM of different origins was acceptable according to standard values used by feed industry. Urease activity was very low (< 0.03 g N/mg x min) for all samples, independent of country of origin. The PDI (19.7 *vs.* 15.3 *vs.*

16.4%) and KOH (86.6 *vs.* 82.6 *vs.* 81.6) values were higher for SBM from the USA than for the BRA or ARG meals. Also, TIA values were higher for USA meals than for BRA or ARG meals (3.5 *vs.* 2.9 and 2.8 mg/g, respectively). Protein dispersibility index and KOH were positively related with TIA of the meals (+0.70 and 0.73, $P < 0.001$ for USA; +0.62 and +0.65, $P < 0.001$ for ARG; +0.27 and +0.44, $P < 0.05$ for BRA, respectively). Heat Damage Index (Aminored) was lower for USA than for ARG SBM and for both lower than for BRA SBM (8.8 *vs.* 12.5 *vs.* 15.6). The HDI values were negatively related (- 0.90, $P < 0.001$) to Lys profile (%CP) for all origins. These results might indicate that more heat was applied to the soybeans during the processing of oil extraction in BRA and ARG than in the USA.

Table 1. Influence of origin (O) of the beans and period of collection (Pr) of samples on chemical composition (% dry matter basis) and protein quality variables of soybean meal.

	Argentine		Brazil		USA			Probability		
Period	5-y[1]	2012	5-y	2012	5-y	2012	SD[2]	O	Pr	OxPr
n	126	30	114	30	149	30				
Chemical composition										
Crude protein	51.6	52.1	52.9	53.5	53.9	52.5	1.63	***	NS	***
Ether extract	1.94	1.95	2.04	2.06	1.84	1.96	0.55	NS	NS	NS
Crude fiber	5.51	4.55	6.37	5.81	4.26	4.24	1.05	***	***	**
NDF	10.7	8.84	12.0	11.6	8.82	9.25	1.67	***	**	***
Sucrose	7.56	7.78	6.56	6.14	8.13	8.94	0.98	***	NS	***
Stachyose	5.57	5.85	5.32	4.86	6.44	6.62	0.53	***	NS	***
Raffinose	1.31	1.51	1.59	1.49	1.09	1.20	0.28	***	NS	***
Minerals										
Ash	7.46	7.54	7.07	7.24	7.55	7.52	0.55	***	NS	NS
Calcium	0.37	0.36	0.32	0.34	0.37	0.45	0.08	***	**	***
Phosphorus	0.74	0.77	0.69	0.72	0.79	0.77	0.05	***	**	***
Potasium	2.56	2.58	2.28	2.39	2.53	2.40	0.20	***	NS	***
Protein quality variables										
UA[4]	0.02	0.01	0.03	0.02	0.02	0.02	0.03	**	NS	NS
TIA[5]	2.83	2.71	2.89	3.04	3.58	3.19	0.71	***	NS	NS
PDI[6]	17.0	13.6	15.3	15.3	19.9	18.5	4.01	***	**	*
KOH[7]	82.4	77.7	83.7	78.3	87.3	82.5	3.58	***	***	NS
HDI[8]	13.2	10.5	16.2	14.0	9.67	5.07	4.26	***	***	NS
Amino acids (% CP)										
Lys	6.09	6.12	6.05	6.07	6.15	6.21	0.06	***	***	NS
Met	1.36	1.38	1.33	1.34	1.36	1.38	0.02	***	***	**
Met+Cys	2.86	2.91	2.80	2.85	2.86	2.92	0.05	***	***	NS
Thr	3.93	3.95	3.89	3.88	3.91	3.93	0.03	***	***	***
Trp	1.37	1.38	1.34	1.35	1.36	1.38	0.02	***	***	***
Sum of the 5 key AA	14.3	14.4	14.1	14.1	14.3	14.4	0.12	***	***	*

*** $P < 0.001$; ** $P < 0.01$; * $P < 0.05$; NS, no significant ($P > 0.05$);
[1]2007-2011 yrs; [2]Standard deviation; [3]Urease activity (mg N/g x min); [4]Trypsin inhibitors activity (mg/g); [5]Protein dispersibility index (%); [6]KOH solubility (%); [7]Heat damage index (Aminored).

The differences in nutrient content of the SBM among the 3 countries were similar in 2012 than in the previous 5 yr period (Table 1). The average CP, sugars and K content of the SBM, independent of country of origin, were similar in the 2 periods considered. However, ARG and BRA meals have less crude fiber (*P < 0.001*) and NDF (*P < 0.01*) in 2012 than in the previous 5 yr period. Also, amino acid profile independent of origin was higher for SBM of the 2012 crop than for the average of the 5 previous year crops. In addition, interactions (*P < 0.001*) between origin and period of collection showed that differences on nutrient content of SBM cannot be estimated by average values. For example, in 2012 USA meals had less CP (52.5 *vs.* 53.9%; *P < 0.05*) and more sucrose (8.9 *vs.* 8.1%; *P < 0.05*) than in the previous 5 yr period, but ARG and BRA meals had similar content for both nutrients in those yr periods.

The relationships between selected nutrients of meals were determined for each country to highlight the influence of the origin of the bean on nutritive value of meals (Table 2). The CP content was negatively related (*P<0.001*) to NDF for ARG and BRA, and to sucrose for USA meals. The oligosaccharide content was positively related (*P<0.001*) to sucrose for ARG and BRA, but no relation was found for USA meals. The P content was positively related (*P<0.01*) to CP and negatively to NDF content, independent of origin. The Lys profile of CP was negatively related (*P < 0.001*) to CP content for USA but positively for BRA meals, and no relation (*P > 0.05*) was observed for ARG meals.

Table 2. Pearson coefficients of correlation (*r*) according origin of the beans between selected chemical components of soybean meals.

	CP[1]	NDF	Oligosac.[2]	Sucrose	P[3]	Lys (%CP)
Argentine (n = 156)						
CP	1	- 0.64***	0.29**	0.05^{NS}	0.27**	- 0.10^{NS}
NDF		1	- 0.34***	- 0.19^{NS}	- 0.40***	- 0.26**
Oligosac.			1	0.56***	0.37***	0.39***
Sucrose				1	0.17^{NS}	0.18^{NS}
P					1	0.17^{NS}
Lys (% CP)						1
Brazil (n = 144)						
CP	1	- 0.43***	- 0.14^{NS}	- 0.05^{NS}	0.31***	0.30***
NDF		1	- 0.15^{NS}	- 0.30***	- 0.27**	- 0.35***
Oligosac.			1	0.40***	- 0.15^{NS}	0.11^{NS}
Sucrose				1	- 0.05^{NS}	0.44***
P					1	0.25**
Lys (% CP)						1
USA (n = 179)						
CP	1	- 0.02^{NS}	0.22**	- 0.70***	0.60***	- 0.49***
NDF		1	- 0.07^{NS}	- 0.33***	- 0.32**	- 0.25***
Oligosac.			1	- 0.12^{NS}	0.25*	0.05^{NS}
Sucrose				1	- 0.36***	0.62***
P					1	- 0.11^{NS}
Lys (% CP)						1

*** *P < 0.001*; ** *P < 0.01*; * *P < 0.05*; NS, no significant (*P > 0.05*);
[1]Crude protein; [2]Oligosaccharides (raffinose + stachyose); [3]Phosphorus.

Conclusions

Nutritive values of the SBM varied widely among origins and crop years. The USA meals had more crude protein, phosphorus, and sucrose but less insoluble fiber than BRA and ARG meals. On CP bases, Lys is higher for USA than for BRA and ARG meals. For other indispensable amino acids, similar content on CP bases were observed for USA and ARG, and for both origins were higher than for BRA meals. The USA meals had higher KOH solubility, PDI, and TIA, but lower HDI values than ARG or BRA SBM. The year of collection influenced nutritive values of SBM but the differences among origins are maintained. Therefore, SBM has to be analyzed frequently to better evaluate its nutritional value.

It is concluded that country of origin should be considered in the evaluation of the nutritive value of commercially available SBM, and origin of the beans should be specified in feed tables for accurate and precise formulation of poultry diets by the feed industry.

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